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L7: Entry 37 of 38 File: USPT Apr 16, 1996

09/90/374

DOCUMENT-IDENTIFIER: US 5508733 A
TITLE: Method and apparatus for selectively receiving and storing a plurality of video signals

Brief Summary Paragraph Right (12):
Conventional television and cable television (CATV) broadcasting are generally carried out on a real-time basis. For instance, it takes the same length of time to broadcast or transmit a TV program than it does to receive and display the program. Such broadcasting method has proven to be less than completely desirable due to limited TV bandwidth and channels allocation.

Brief Summary Paragraph Right (23):
As a quasi-closed loop, private video conferencing system, Boerger is not concerned with, and does not address the issue of video channel availability. For all practical purposes, each one of the large and small picture signals can be assigned its own transmission bandwidth (column 3, lines 30-40), without regard to the compression requirements. This holds particularly true if the connecting lines 36 and return channels 37 are actual cable lines as opposed to television or satellite telecommunications channels.

Brief Summary Paragraph Right (56):
While the video digitization and compression techniques disclosed in the foregoing patents have proven to be adequate for their intended purposes, there is no completely adequate teaching of a Program Delivery System (PDS) which is capable of simultaneously delivering multiple signals from different origins or sources, such as video, audio and/or data (VAD). The PDS should also allow program suppliers to provide multiple programs per transponder channel, such as a satellite transponder channel, to cable, television or other systems headends or end users. One application for the PDS should be to provide multiple video outputs with multiple audio channels and VBI text signals for each video output. Another application of the PDS should be to provide various degrees of compression for different combinations of video, audio and/or data (VAD) signals.

Brief Summary Paragraph Right (64):
U.S. Pat. No. 5,109,414 is exemplified by claims 1 and 18 through 26, and relates to an automation system for local broadcast stations and cable TV headends, for handling spot commercials, and for inserting them locally in ad supported television networks; and to the automatic operation of local recorders/players and switching systems (claims 25 and 26). The patent also describes an automation system for computer networks and server nodes in recording and routing data packets and inputting them to processors (claims 18, 19, 23 and 24). It also relates to the feature of automation of multimedia and multiple media presentations at receiver stations (claims 18 through 26).

Brief Summary Paragraph Type 1 (38):
12. U.S. Pat. No. 4,646,135 by Eichelberger, entitled "System for Allowing Two Television Programs Simultaneously to Use the Normal Bandwidth for One Program by Chrominance Time Compression and Luminance Bandwidth Reduction", and assigned to General Electric Co.

Brief Summary Paragraph Type 1 (46):
3. U.S. Pat. No. 3,883,686 to Jacobacus et al., entitled "Method to Reduce the Effect of a Loss of Information during the Transmission Compressed Band Width and Device for Carrying out the Method" and assigned to T. L. M Ericsson of Sweden, generally relates to a technique for reducing the effect of loss of information during transmission at compressed bandwidth of a PCM-signal. A PCM coder converts the analog video signal to a

PCM signal such that the picture elements in the video signal will be the equivalent to PCM words having binary values which are equivalent to respective light intensities of the picture elements.

Detailed Description Paragraph Right (2):
In conventional television or video broadcasting systems, the channels 1 through n are received and then displayed on a real time basis as corresponding channels 1 through n. These channels generally occupy the entire bandwidth at the receiver end. Thus, the channel availability in conventional broadcasting systems is severely limited by the allocated TV bandwidth. This bandwidth is generally pre-assigned, and thus not expandable. Since each one of the received channels also generally has a fixed bandwidth, the number of channels cannot be increased.

Detailed Description Paragraph Right (3):
Therefore, the present broadcasting method 10 (FIG. 1) and system 200 (FIG. 3) offer a valuable advantage over the conventional methods and systems, in that the present method and system enable the accommodation of a significantly larger number of channels in the limited TV or video bandwidth of the receiver, and enable the broadcasting of an increased number of channels over the existing video bandwidth.

Detailed Description Paragraph Right (4):
The transmission process 12 generally includes multiplexing signals from a plurality of channels 1 through n, prior to transmission. The multiplexed signals are then transmitted over a single base carrier frequency. The channels 1 through n generally occupy the entire allocated television or video bandwidth.

Detailed Description Paragraph Right (37):
Let us take a hypothetical example to illustrate the improvements presented by the alternate embodiment. If for instance 50 channels can be transmitted over a conventional television bandwidth, the preferred embodiment will allow the transmission of at least 100 channels, while the alternate embodiment will permit the selective transmission of over 200 channels.

Detailed Description Paragraph Right (218):
FIGS. 29 and 30 provide additional details of the ground station GS.sub.1 of FIG. 25, and illustrate the interdependence of the video, audio and data channels VC.sub.1, VC.sub.2, AC.sub.1 through AC.sub.P, and DC.sub.1 through DC.sub.Q. These figures illustrate an important aspect of the present invention, namely that the video, audio and data signals are compressed through the selective allocation of video harmonic frequencies, and that the audio and data channels are modulated at video frequencies and treated as if they were video channels. The bandwidth of the video channels will enable high quality compression of a significant number of audio and data channels. FIG. 29 shows a central video switching exchange (CVSE) 989, which allows for the compression, modulation and multiplexing of the video, audio and data signals, as shown in the marker channels of FIG. 30.

Detailed Description Paragraph Right (221):
More particularly, for cable television (CATV) applications, the CATV headend unit conforms to short haul specifications, and the consumer units conform to medium haul specifications. Additionally, the frequency response and other characteristics of the CATV headend units of two exemplary video types (NTSC and RGB) could conform to the following specifications:

Detailed Description Paragraph Right (228):
The video channel VC.sub.1 is illustrated by the two marker channels MC.sub.1 and MC.sub.2 of FIG. 30, as comprising three video bands V.sub.1, V.sub.2 and V.sub.3. Each one of these bands includes several sub-bands, such as the sub-bands 901 through 909, corresponding to particular video frequencies such as R (i.e. sub-band 901), G (i.e. sub-band 902) or B (i.e. sub-band 903). For illustration purposes only the first and second transforms V.sub.R1 [.phi..sub.R1 ] and V.sub.R2 [.phi..sub.R2 ] respectively of the component signal V.sub.1R are selected to be processed by the Fourier selector 807, as shown in sub-band 901, thus reducing equation (22) to:

Detailed Description Paragraph Right (229):
Sub-band 903 in marker channel MC.sub.2 illustrates that only the first transform V.sub.G1 [.phi..sub.G1 ] of the signal V.sub.1G has been selected, thus reducing equation (23) to:

Detailed Description Paragraph Right (230):

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L7: Entry 32 of 38 File: USPT Feb 17, 1998

DOCUMENT-IDENTIFIER: US 5719872 A
TITLE: Reverse path allocation and contention resolution scheme for a broadband communications system

Brief Summary Paragraph Right (4):
Since the pioneer days, cable networks have experienced enormous growth and expansion in the United States, particularly in urban networks. It is estimated that CATV networks currently pass approximately 90% of the population in the United States, with approximately 60-65% of all households actually being connected. While cable systems originally had very simple architectures and provided a limited number of different television signals, the increase in the number of television broadcasters and television owners over the last several decades has resulted in much more complex and costly modem cable distribution systems.

Brief Summary Paragraph Right (5):
A typical CATV system comprises four main elements: a headend, a trunk system, a distribution system, and subscriber drops.

Brief Summary Paragraph Right (6):
The "headend" is a signal reception and processing center that collects, organizes and distributes signals. The headend receives satellite-delivered video and audio programming, over-the-air broadcast TV station signals, and network feeds delivered by terrestrial microwave and other communication systems. In addition, headends may inject local broadcasting into the package of signals sent to subscribers such as commercials and live programming created in a studio.

Brief Summary Paragraph Right (7):
The headend contains signal-processing equipment that controls the output level of the signals, regulates the signal-to-noise ratio, and suppresses undesired out-of-band signals. Typical signal-processing equipment includes a heterodyne processor or a demodulator-modulator pair. The headend then modulates received signals onto separate radio frequency (RF) carriers and combines them for transmission over the cable system.

Brief Summary Paragraph Right (8):
The "trunk system" is the main artery of the CATV network that carries the signals from the headend to a number of distribution points in the community. A modern trunk system typically comprises of a combination of coaxial cable and optical fibers with trunk amplifiers periodically spaced to compensate for attenuation of the signals along the line. Such modern trunk systems utilizing fiber optics and coaxial cable are often referred to as "fiber/coax" systems.

Brief Summary Paragraph Right (12):
Cable distribution systems were originally designed to distribute television and radio signals in the "downstream" direction only (i.e., from a central headend location to multiple subscriber locations, also referred to as the "forward" path). Therefore, the component equipment of many older cable systems, which includes amplifiers and compensation networks, is typically adapted to deliver signals in the forward direction only. For downstream transmissions, typical CATV systems provide a series of video channels, each 6 MHz in bandwidth, which are frequency division multiplexed across the forward band, in the 50 MHz to 550 MHz region of the frequency spectrum. As fiber is moved more deeply into the serving areas in fiber/coax and FTSA configurations, the bandwidth of the coax portion is expected to increase to over 1 GHz.

Brief Summary Paragraph Right (13):

The advent of pay-per-view services and other interactive television applications has fueled the development of bidirectional or "two-way" cable systems that also provide for the transmission of signals from the subscriber locations back to the headend. This is often referred to as the "upstream" direction or the "reverse" path. This technology has allowed cable operators to provide many new interactive subscriber services on the network, such as impulse-pay-per-view (IPPV). In many CATV systems, the band of signals from 5 MHz to 30 MHz is used for reverse path signals.

Brief Summary Paragraph Right (14):
However, the topology of a typical CATV system, which looks like a "tree and branch" with the headend at the base and branching outwardly to the subscriber's, creates technical difficulties in transmitting signals in the upstream direction back to the headend. In the traditional tree and branch cable network, a common set of downstream signals are distributed to every subscriber home in the network. Upstream signals flowing from a single subscriber toward the headend pass by all the other upstream subscriber homes on the segment of distribution cable that serves the neighborhood.

Brief Summary Paragraph Right (15):
The standard tree and branch topology has not proven to be well suited for sending signals from each subscriber location back to the headend, as is required for bidirectional communication services. Tree and branch cable distribution systems are the most efficient in terms of cable and distribution usage when signals have to be distributed in only the downstream direction. A cable distribution system is generally a very noisy environment, especially in the reverse path. Interfering signals may originate from a number of common sources, such as airplanes passing overhead or from Citizens Band (CB) radios that operate at a common frequency of 27 MHz, which is within the typical reverse channel bandwidth of CATV networks. Since the reverse direction of a tree and branch configuration appears as an inverted tree, noise is propagated from multiple distribution points to a single point, the headend. Therefore, all of the individual noise contributions collectively add together to produce a very noisy environment and a communications problem at the headend.

Brief Summary Paragraph Right (16):
Present day FTSA systems facilitate the communication of signals in the reverse direction by dividing the subscriber base of a cable network into manageable serving areas of approximately 400-2500 subscribers. This allows for the reuse of limited reverse band frequency ranges for smaller groups of subscribers. The headend serves as the central hub of a star configuration to which each serving area is coupled by an optical communications path ending in a fiber node. The fiber node is connected to the serving area subscribers over a coaxial cable distribution sub-network of feeders and drops in each serving area. In the FTSA configuration, some of the signals in the forward direction (e.g., television program signals) are identical for each serving area so that the same subscriber service is provided to all subscribers. In the reverse direction, the configuration provides an independent spectrum of frequencies confined to the particular serving area. The FTSA architecture thus provides the advantage of multiplying the bandwidth of the reverse portions of the frequency spectrum times the number of serving areas.

Brief Summary Paragraph Right (18):
Moreover, there is substantial interest expressed by telephone system operating companies in the idea of increased bandwidth for provision of new services to telephone subscribers, such as television; interactive computing, shopping, and entertainment; videoconferencing, etc. Present day "copper" based telephony service (so called because of the use of copper wires for telephone lines) is very bandwidth limited about 3 kHz and cannot provide for such enhanced services by the telephone companies without massive changes to the telephone networks infrastructure.

Brief Summary Paragraph Right (19):
Existing communications systems, however, have not proven to be well suited for the transmission of telephony signals on the cable network. A system for transmitting telephony signals must be configured to allow single point to single point distribution (i.e., from a single subscriber to a single subscriber). However, unlike the telephone companies with their well-established national two-way networks, the cable industry is fragmented into thousands of individual systems that are generally incapable of communicating with one another. The cable network is instead ideally configured for single point to multiple point signal transmission (i.e., from a single headend downstream to multiple subscriber locations).

Brief Summary Paragraph Right (21):

One approach taken to provide a bidirectional broadband communications system is shown in U.S. Pat. No. 5,084,903 of McNamara et al., assigned to First Pacific Networks (hereinafter referred to as "FPN"). This patent describes an approach to the communication of telephony signals that appears primarily designed to operate in an office-type data communications network environment (e.g., Ethernet). Data communications networks are typically bandwidth symmetrical, that is, the forward and reverse signal paths consume equal amounts of bandwidth, and the topology is star or serial, not tree and branch. In contrast, CATV networks are bandwidth asymmetrical, with heavy allocation of bandwidth for use in the downstream direction and limited upstream bandwidth. As the present inventors have discovered, the noise problem in the upstream direction is difficult in a broadband bandwidth-asymmetrical, tree and branch topology, as contrasted with a symmetrical office-type data communications network.

Brief Summary Paragraph Right (22):
The system described in the FPN patent employs two different modulation schemes for communicating information between a central headend and a plurality of subscriber nodes. For downstream communications, the FPN system transmits signals continuously in a plurality of 6 MHz bandwidth channels. In a preferred embodiment, an AM-PSK modulator is used in the downstream path. For upstream communications, the FPN system transmits packets of information in bursts to a headend using an offset quadrature phase shift keyed (OQPSK) modulator.

Brief Summary Paragraph Right (23):
While the FPN communications system may be suitable for communicating telephony signals on a data communications network such as Ethernet, it does not solve certain problems that occur in the carriage of telephony signals on a broadband cable network. Due to the single point to multiple point configuration (tree and branch) of the CATV network, upstream transmissions of telephony signals have to contend with multiple noise sources as the branch signals from each subscriber are merged together toward the headend. It is believed, however, that the burst mode approach used in the reverse path of the FPN system is particularly susceptible to these noise issues. Specifically, it is believed that the framing bits and sequencing of the data streams are susceptible to interruption when an interference signal is sustained for any significant length of time (i.e., for longer than the length of a data frame) anywhere within one of the 6 MHz bandwidth channels used to carry telephony signals.

Brief Summary Paragraph Right (27):
Existing broadband communications systems are impractical for implementing statistical multiplexing on the cable network because they fail to provide suitable mechanisms for allocating bandwidth to a large number of subscribers, particularly in the reverse or upstream path. Because the bandwidth available for upstream telephone communications is limited in a cable network, it is often necessary for multiple subscribers to share reverse path frequencies in order to maximize the number of subscribers that can utilize the system. If more than one subscriber attempts to access the same channel, some mechanism must be provided to resolve the contention between them. Moreover, the contention resolution must be very quick, so that the subscriber is not inconvenienced while the communication channels are being set up.

Brief Summary Paragraph Right (28):
Therefore, a broadband communications system should provide a scheme for allocating the limited bandwidth to these subscribers and for ensuring that at any given time any subscriber may have immediate access to a reverse communications channel. Furthermore, a broadband communications system should provide a mechanism for resolving the contention for bandwidth that will inevitably occur among subscribers that share the same reverse frequency.

Brief Summary Paragraph Right (30):
There is also a need for a broadband communications system that is bandwidth efficient and provides a higher spectral efficiency than present systems, thereby increasing the number of subscribers that may be served by each broadband network with telephony and enhanced services offered by CATV system operators, telephone company operating companies, and others.

Brief Summary Paragraph Right (31):
There is also a need for a broadband communications system that provides a suitable mechanism for allocating bandwidth to the largest number of subscribers possible.

Brief Summary Paragraph Right (33):
There is a further need for a broadband communications system that provides a suitable

mechanism for resolving contention for bandwidth among multiple subscribers that share reverse path frequencies.

Brief Summary Paragraph Right (37):
In another preferred embodiment, the method includes the digitizing of individual subscriber telephony signals into a multiplexed signal that is carded on a frequency division multiplexed (FDM) carrier in the forward band of the cable network. The digital multiplexed signal is quadrature partial response (QPR) modulated on a carrier which is positioned in an otherwise unused portion of the CATV network forward band. In the illustrated embodiment, the QPR signal is preferably approximately 3 MHz in bandwidth and easily fits in a standard 6 MHz video channel. In another preferred embodiment, a pair of the QPR signals can be placed in an otherwise unused channel in the cable line to utilize approximately 6 MHz of bandwidth. By making a system which uses a robust digital signal, the bandwidth of the forward CATV band can be efficiently allocated. The system operator can plan and change these allocations on a flexible basis as new services are made available or old services are taken off line.

Brief Summary Paragraph Right (38):
In a preferred embodiment, the subscriber telephony signals to the telephony network are digitized and individually modulated on a carrier in the reverse band of the CATV system. As an illustrated example, a subscriber DS0 telephony line is QPSK modulated into an approximately 50 kHz bandwidth signal (e.g. 49.5 kHz) and frequency division multiplexed on the reverse band of the CATV network. The individual telephony signals are multiplexed into a standard time-division multiplexed (TDM) telephony signal which can be adapted to couple directly into a SONET port or other standard telephony connection, such as a DS1, DS2, or DS3 format signal, of the telephony network.

Brief Summary Paragraph Right (40):
The number of subscribers served by the telephony service can be increased several fold if the CATV network is a FTSA network. The space (frequency) division multiplexing (FDM) used in the reverse band makes it economical to provide a substantial number subscribers in a serving area with a telephony service. If a serving area contains 500 subscribers, then the bandwidth needed for a dual path system at about 50 kHz per subscriber would be 25 MHz, within the 5-30 MHz reverse band of the most prevalent split band systems.

Brief Summary Paragraph Right (41):
According to another aspect of the invention, the reverse band circuitry is frequency agile, and is responsive to channel information provided in a data link or directory channel in the forward band from the headend interface unit for tuning to one or more selected reverse band frequencies, for modulating the telephony signals from the customer interface unit in the one or more selected frequency subbands. The frequency agile feature permits the selective allocation of bandwidth to satisfy subscriber demands and change of reverse band channels in response to noise in a channel. The frequency agility permits the invention to carry out dynamic bandwidth allocation to effect varying levels of service for subscribers, e.g. single voice line, multiple voice line, ISDN, data communications, etc., and avoid particular reverse band channels that are susceptible to and/or are experiencing noise.

Brief Summary Paragraph Right (42):
According to another aspect of the invention, the system is operative to determine an appropriate service level to provide communications to a particular subscriber, and allocate one or more selected frequency subbands in the reverse band of the subscription network so as to provide selectably variable bandwidth commensurate with the determined appropriate service level. The identity of the one or more selected frequency subbands are communicated to the particular subscriber in a data link or directory channel in a forward band. Incoming telephony signals are communicated to the particular subscriber in the forward band of frequencies, as in other embodiments of the invention. At the subscriber terminal associated with the particular subscriber, the identity of the one or more selected frequency subbands for communications back to the headend is received via monitoring the data link or directory channel. Subscriber telephony signals are then communicated to the headend in the one or more selected frequency reverse frequency subbands.

Brief Summary Paragraph Right (43):
In the alternative frequency agile embodiment, a pair of subscriber DS0 telephony lines are QPSK modulated into a 108 kHz bandwidth signal, with 20 kHz guard band, and frequency division multiplexed on the reverse band of the CATV network. In this embodiment, there is capacity for handling 388 DS0 equivalent telephony channels in the

5 MHz to 30 MHz reverse band. To serve 388 subscribers with a single DS0 telephony service, then the bandwidth needed for a dual path system is as follows: 194 upstream channels, each channel carrying 2 DS0's, each channel at 128 kHz, yielding about 25 MHz, positioned within the 5-30 MHz reverse band of the most prevalent split band systems.

Brief Summary Paragraph Right (46):
As described, one of the primary advantages of the present invention is its frequency agility, and the ability to allocate bandwidth to subscribers on demand. The frequency agile feature is preferably provided in the reverse band of the communications system, and is operative for modulating a telephony signal from a subscriber in one or more frequency subbands in the reverse band of the subscription network so as to provide selectably variable bandwidth in the second band commensurate with selected subscriber communication features. For example, a subscriber can subscribe to a single voice grade line telephone service, plural voice grade telephone line service, ISDN telephone service, local or wide area network communication services (e.g. ETHERNET, Appletalk), security monitoring communication services, or the like.

Brief Summary Paragraph Right (47):
The present invention therefore differs from conventional systems by providing dynamic frequency assignment, in which each subscriber is allocated bandwidth on demand. This approach provides the ability to change the frequency if an interfering carrier is introduced during the course of a conversation.

Brief Summary Paragraph Right (48):
According to yet another aspect of the invention, the preferred system provides each subscriber premises with a unique address that is permanently configured in the CIU such as a FLASH ROM or PROM. This allows the headend of the cable system to communicate with each CIU individually. When a subscriber communicates with the headend to request telephony service, the headend can verify the levels of subscriber service or features that are authorized for the requesting subscriber, and appropriate bandwidth (e.g. DS0 channels) can be allocated commensurate with the authorized and requested level of service or feature.

Brief Summary Paragraph Right (49):
According to yet another aspect of the invention, the preferred system also provides for the ability to monitor or verify signal performance at any time. The alternative embodiment carries out steps of monitoring the noise level in the 128 kHz subbands provided in the reverse spectrum, and changing the frequency of a selected subband allocated for provision of service to a selected subscriber in response to a determination that the noise level in the monitored subband exceeds a predetermined threshold. This permits dynamic reallocation of telephony signal from a particular region in the reverse channel spectrum that may be subject to noise or interference, so as to move the reverse band communication to a region of the spectrum that is cleaner.

Brief Summary Paragraph Right (51):
A system constructed in accordance with the present invention provides the further advantage of compatibility with a growing market. As cable operators begin to provide telephony service over the cable network, it may be desirable not to have to initially allocate the entire reverse bandwidth for upstream telephony signals. Likewise, as telephony applications increase, it may be desirable to allocate more bandwidth to telephony applications than nominal 25 MHz provided in the disclosed embodiment. Ideally, the cable operators would like to deploy hardware and modify architectures as the consumer demand dictates. Furthermore, there may be instances where a subscriber may have an application that has a higher bandwidth requirement (e.g., video teleconferencing at 384 kbps). Systems that assign a predetermined, unchangeable segment of bandwidth to each subscriber, however, do not have the flexibility to expand or selectably allocate bandwidth in response to demand. Instead, each subscriber must be provided with hardware established at a certain frequency. The present invention, instead of assigning each subscriber a dedicated frequency, allocates as many channels as needed in response to demands for a particular level of service. Thus, the present system can provide subscribers with services such as video teleconferencing, fax lines, multiple voice lines, ISDN, etc. as needed.

Brief Summary Paragraph Right (52):
According to yet another aspect of the present invention, the broadband communications system includes reverse path contention resolution equipment for detecting contention by plural subscribers to a selected frequency subband in second or reverse band of frequencies, and reassigning subscribers to a different frequency subband in the second

band.

Brief Summary Paragraph Left (4):
Bandwidth Allocation and Contention Resolution

Drawing Description Paragraph Right (18):
FIG. 11 is a block diagram of a headend interface unit (HIU) constructed in accordance with an alternative embodiment of the present invention.

Drawing Description Paragraph Right (21):
FIG. 14 is a detailed block schematic diagram of the reverse demodulator converter utilized in the headend unit (HIU) illustrated in FIG. 10.

Drawing Description Paragraph Right (22):
FIG. 15 illustrates a service level table maintained by the headend unit (HIU) of FIG. 11 to allocate varying service levels requested by subscribers with various reverse channel frequencies.

Drawing Description Paragraph Right (23):
FIG. 16 illustrates the method carried out in the alternative HIU and CIU of FIGS. 11 and 12 for dynamic bandwidth allocation and frequency assignment in the reverse channels.

Drawing Description Paragraph Right (26):
FIG. 19 illustrates the method carried out in the alternative HIU and CIU of FIGS. 11 and 12 for reverse path bandwidth allocation and contention resolution.

Detailed Description Paragraph Right (2):
By "headend", we do not mean to be limited to a conventional coaxial CATV headend such as 14, but also consider that an optical fiber node such as 16 or other communication node that can serve the functions of receiving multiplexed communication signals from a source of signals, such as a telephony central office, and communicating such signals to subscribers in the broadband network. As will be seen in the following discussion, a CATV headend 16 is the preferred embodiment for effecting these functions.

Detailed Description Paragraph Right (4):
The CATV network 12 is illustrated as having a fiber to the serving area (FTSA) architecture. A headend 14 provides CATV programming which is distributed via a distribution network to a plurality of subscribers at their subscriber premises 30. The distribution network serves a plurality of "serving areas", such as the one referenced at 20, which are groups of subscribers that are located proximate to one another. Each serving area is comprised of groups ranging in size from about 50 homes to about 2500 homes. The headend 14 is coupled to each serving area in a star configuration through an optical fiber 18 which ends in a fiber node 16. The CATV programming and telephony signals are converted from an RF broadband signal to light modulation at the headend 14, transmitted over the optical fiber 18, and then converted back to an RF broadband signal at the fiber node 16. Radiating from each of the fiber nodes 16 throughout its serving area 20 is a coaxial sub-network of feeders 22 having bidirectional amplifiers 24 and bidirectional line extenders 25 for boosting the signal.

Detailed Description Paragraph Right (5):
The RF broadband signal is distributed to each of the subscriber premises 30 by tapping a portion of the signal from the nearest feeder 22 with a tap 26, which is then connected to the subscriber premises through a standard coaxial cable drop 28. The CATV network thus provides a broadband communications path from the headend 14 to each of the subscriber premises 30, which can number in the several hundreds of thousands.

Detailed Description Paragraph Right (6):
While one preferred embodiment of the invention shows the input interface 32 coupled to the fiber node 16 and the output interface 34 coupled to the headend 14, it is evident that the insertion and extraction of the RF telephony signals need not be limited to this single architecture. Both the input interface 32 and an output interface 38 (shown in phantom) can be connected at the fiber node 16. Alternatively, both an input interface 36 (shown in phantom) and the output interface 34 can be coupled to the headend 14. Moreover, the input interface 36 can be coupled to the headend 14, while the output interface 38 can be coupled to the fiber node 16. For cable architectures which do not conform to a star configuration, it is generally most advantageous to insert the RF telephony signals at the headend and to extract them from the system at the headend. Each architecture has its own distinct advantages as will be more fully

described hereinafter.

Detailed Description Paragraph Right (8):
Theoretically, the broadband communications path provided by the CATV network 12 is bidirectional so that information can be passed in each direction. However, because of convention and the single point to multipoint nature of most networks, the reverse path, i.e., communications originating from the subscriber premises 30 and communicated to the headend 14, is much more limited. Normally, the reverse amplifiers 25 are bandwidth limited and include diplexers which separate the CATV spectrum into forward and reverse paths based on frequency.

Detailed Description Paragraph Right (11):
Additionally, the switch 41 has means for demultiplexing DS1 signals into a plurality of DS0 signals which then can be routed to outgoing points. The system uses a forward path which receives a plurality of the DS1 channels at the input interface 32 and connects them over the CATV network 12 to the subscriber premises 30. The subscriber premises 30 transmits telephony signals over the CATV network 12 to the output interface 34 which converts them back into the same number of DS1 signal channels for transmission to the switch 41. If the switch 41 is located proximately to the input interface 32 and the output interface 34, then they can be coupled directly. Alternatively, as will be the most prevalent case, where a headend or fiber node is not located proximately to the class 5 switch, an optical fiber link can be used to connect the switch 41 and interfaces 32 and 34.

Detailed Description Paragraph Right (15):
FIG. 3A illustrates a typical frequency allocation for many of the installed split band CATV networks. The frequencies used for programming which generate the revenues for the system operator are carried in the forward band from 50 MHz to about 550 MHz. Although, the frequencies above 550 MHz are not presently used, there has been increased interest in providing additional services in this unused forward bandwidth, currently considered to extend to, about 1 GHz. Conventionally, the forward band comprises a series of video channels, each 6 MHz in bandwidth, which are frequency division multiplexed across the forward band. Several areas are not used and each video channel has a 1.5 MHz guard band between other adjacent channels.

Detailed Description Paragraph Right (16):
In combination with the forward band, the typical CATV spectrum includes a reverse band from about 5-30 MHz. These frequencies have been allocated for signals returning from the subscriber to the headend. This band has traditionally been relatively narrow because of the high noise from the funneling effects of the multiplicity of the multipoint signals adding to a single point. Further, in the past bandwidth taken from the forward band has meant less revenues from other services. The present invention provides a solution to these problems by providing a system where the telephony signals to a subscriber premises are communicated in the forward band of the spectrum and the telephony signals from a subscriber premises are communicated in the reverse band of the CATV system.

Detailed Description Paragraph Right (18):
Each of the reverse band signals are about 50 kHz in bandwidth (49.5 kHz in the presently preferred embodiment), which is narrow enough to be easily placed at different frequency division multiplexed positions in the frequency spectrum. The modulators are frequency agile and can reallocate frequencies based upon traffic over the system, noise, channel condition, and time of use. The 49.5 kHz wide carriers can be placed anywhere in the reverse band that there is space for them. Depending upon the CATV system, i.e., whether there is a reverse amplification path in the distribution network, they could also be allocated to frequencies normally reserved for forward band transmissions. Further, such system is expandable by bandwidth for other uses besides the individual telephony signals. For example, if a particular subscriber required a return path of a greater bandwidth than 49.5 kHz, then the bandwidth could be easily allocated to this use without a complete reconfiguration of the system. Such uses may include high speed data transmissions, trunk connections for small central offices, video services originating from the telephony network, and other uses requiring a nonstandard bandwidth.

Detailed Description Paragraph Right (20):
FIG. 3C illustrates an alternative frequency allocation for a split band CATV network that is implemented in an alternative embodiment of the present invention, described in connection with later figures. As in prior embodiments, the frequencies used for television programming that generate the revenues for the system operator are generated

in the forward band from about 50 MHz and above. The spectrum in FIG. 3C includes the reverse band from about 5 MHz to about 30 MHz. The 5-30 MHz band is used for upstream telephony signals in the form of 388 DS0's, combined to form DS0 pairs and QPSK modulated in 128 kHz upstream channels or subbands designated UP1, UP2, . . . UP194, where each upstream channel UPn carries 2 DS0's. Thus, in order to accommodate 388 DS0's, 194 QPSK carriers or channels are required. Each of the upstream channels UPn consumes 128 kHz bandwidth, comprising 108 kHz of modulated signal space and 20 kHz of guard band. The modulated digital signals are as formatted as described in connection with FIG. 9B.

Detailed Description Paragraph Right (21):
The downstream telephony is provided in downstream channels DN1, DN2 . . . DN480, each DN corresponding to a DS0. In one preferred alternative embodiment, a total of 21 MHz of bandwidth is provided in 3.168 MHz subbands, each 3.168 MHz subband carrying the equivalent of three DS1 telephony signals (72 DS0's), in QPR modulation, formatted as described in connection with FIG. 9C.

Detailed Description Paragraph Right (31):
The telephony signals are demodulated by the tuner/demodulator 92 into a serial digital stream containing the 3 DS1 or 3 E-1 telephony signals before being input to the demultiplexer 96. The demultiplexer 96 selects the particular DS0 digital telephony channel assigned to the subscriber at the input rate of 64 kb/s and inputs the data to an input terminal of the line card 98. The control unit 90 determines which forward telephony channel to tune and which DS0 signal to select from that channel from the signal and addressing information it receives by its connection to the splitter/combiner/diplexer 80 via line 89.

Detailed Description Paragraph Right (32):
The DS0 digital format provides a voice channel with sufficient bandwidth for voice quality communications. The DS0 format is a 64 kb/s data stream of bytes forming timed samples of an analog voice signal. This produces a voice signal quantized to 8-bits per sample (256 values) at a sampling rate of 8 kHz and with a bandwidth of 4 kHz.

Detailed Description Paragraph Right (34):
The modulator 94 under the regulation of the control unit 90 selects a carrier frequency in the reverse band and QPSK modulates the DS0 telephone signal thereon. The QPSK modulated carrier having a bandwidth of 49.5 kHz is coupled on the CATV network through the splitter/combiner/diplexer 80.

Detailed Description Paragraph Right (42):
Then, a randomizer 104 acts on the data to distribute the energy of the signal over longer time periods. It is known that such randomization is beneficial for the clock recovery circuits of the demodulators at the central or headend location. The randomization is accomplished by generating a pseudorandom bit string (a "PRBS"), and then adding it byte by byte to the data signal. The longer and more random the string, the more randomizing effect that such operation has on the data. The PRBS can be generated in many ways, but the simplest is with a shift register which continually recirculates the sequence wherein the preferred implementation a 127 bit pattern is used. The output, as is well known, can be derandomized by subtracting the same sequence in the same order which it was added to the bit stream

Detailed Description Paragraph Right (46):
One of the primary advantages of the present invention is its frequency agility, and the ability to allocate bandwidth to subscribers on demand. The frequency agile feature is preferably provided in the reverse band of the communications system, and is operative for modulating a telephony signal from a subscriber in one or more frequency subbands in the reverse band of the subscription network so as to provide selectably variable bandwidth in the second band commensurate with selected subscriber communication features. For example, a subscriber can subscribe to a single voice grade line telephone service, plural voice grade telephone line service, ISDN telephone service, local or wide area network communication services (e.g. ETHERNET, Appletalk), security monitoring communication services, or the like.

Detailed Description Paragraph Right (48):
Referring back to FIG. 8, the RF modulator 106 accepts a 72 kbps data stream to QPSK modulate a RF carrier (5 MHz to 30 MHz) and transmits the information via the coaxial cable subnetwork in a 49.5 kHz channel to the headend. The digital data is split into I and Q channels by the encoder 108 and differentially encoded to remove phase ambiguity in the carrier recovery at the receiving end. The I and Q channels of encoded

information are then filtered separately in filters 110 to ensure that the data can be transmitted with a minimum of intersymbol interference. The filters 110 are digitally implemented and approximate a raised cosine filter with an alpha=1.5. Separate filtering at baseband allows for lowpass filters to be used instead of a more complex bandpass at the output of the modulator.

Detailed Description Paragraph Right (51):
The demodulator 480 for the QPSK signal, which is 49.5 kHz in bandwidth, will be more fully described with reference to FIG. 10. The particular carrier frequency in which the QPSK signal is modulated is tuned by a converter 114 having as an input the channel number from the address and control unit 90. The converter 114 selects the particular frequency and converts it to an intermediate frequency, preferably 455 kHz. The intermediate frequency signal is filtered by a band pass filter 116 and then amplified by an amplifier 118 with automatic gain control. The clock for the QPSK signal is recovered through an envelope detector 120 and a band pass filter 122 which passes the symbol rate, in this case 32 kHz to a comparator 124. This clock is used to clock two D-type bistables which sample the I and Q phases of the QPSK signal. The samples of the I and Q phases are differentially decoded and then converted from parallel to serial in converter 126 and thereafter output as a 64 kb/s digital signal.

Detailed Description Paragraph Right (54):
In summary, the present invention provides for broadband communications including digital communications, telephony, and telephony-related services by utilizing a CATV system in an efficient manner, while not requiring extensive switching equipment and a redesign of such systems. The broadband communications system requires no switching in the normal context when connecting telephony based calls from a subscriber or to a subscriber. A multiplicity of calls can be placed through the system efficiently using the broad bandwidth of the CATV network to utilize its best features and having the switching for the connection of the calls performed by the telephony network to utilize its best features.

Detailed Description Paragraph Right (59):
Turning next to FIG. 11, the preferred embodiment of a headend interface unit (HIU) 301 constructed in accordance with an alternative embodiment of the present invention will be described. The alternative HIU 301 is suitable for use either as equipment comprising the headend 14 or equipment comprising the fiber node 16 shown in FIG. 1, both of which are operative for receiving multiplexed digital telephony signals in a standard telephony format such as DS3, DS2, DS1, and coupling such signals to an input interface 32, 36 or an output interface 34, 38. Although the preferred embodiment is described in connection with a coaxial line HIU, it will be understood that the principles are applicable for an optical-fiber based HIU that employs methods for communicating broadband signals via amplitude modulation (AM) methods, such as described in U.S. Pat. No. 5,262,883, which is owned by the assignee of the present invention. Briefly described, the HIU 301 is operative for connecting to a telephone company (telco) standard multiplexed telephony signal, directing incoming telephony signals to subscribers downstream on the broadband network using QPR modulation in the forward path, and receiving outgoing telephony signals from subscribers upstream on the broadband network in one or more selected subbands within the reverse path spectrum, commensurate with service levels or features elected by subscribers.

Detailed Description Paragraph Right (63):
The backplane 305 further includes a CPU bus coupled between a CPU 308 utilized as a database controller and each of the line cards 303 The CPU 308 is operative to control the assigned relationships between particular telephony lines, ingoing and outgoing, with predetermined carrier assignments in the reverse path and in the forward path, monitor the noise level in the reverse path, and assign DS0 channels in the reverse path commensurate with subscriber features and the like. Further, the CPU 308 is operative to carry out steps described below of monitoring noise in the reverse pathway channels as described in connection with FIG. 16, and dynamically allocate bandwidth as described in connection with FIG. 17, and to maintain in memory a service level table as shown in FIG. 15 that indicates the correspondence between reverse channel carrier frequencies, subscriber identification, service level, telco DS0 identification, signaling status, error count for noise monitoring, and the like.

Detailed Description Paragraph Right (71):
The CIU 400 is especially adapted for utilization with selectable bandwidth features or services that may be subscribed to by subscriber, e.g., single line telephony service, multiple line telephony service, ISDN service, data communications service, local or wide area network of data communications such as ETHERNET, or the like.

Detailed Description Paragraph Right (72):
In order to implement the on-demand selectable services and to accommodate the varying bandwidths for such services, the CIU 400 includes one or more line cards 98', which are constructed basically the same as the line card 98 shown in FIG. 6. The alternative line cards 98' are of varying types depending upon the nature of the service that is to be connected. For example, the line card in 98'a is adapted for two conventional voice grade telephony line 402a, 402b that comprise the conventional 2-wire twisted pair copper connections with tip (T) and ring (R) known to those skilled in the art. On the other hand, the line card 98'b is adapted for ISDN and includes a standard ISDN connector. Other types of lines cards 98'n may be provided for connection of other types of customer data service such as local area network data communications (e.g. ETHERNET), security monitoring systems, video teleconferencing, etc.

Detailed Description Paragraph Right (78):
It will be understood that the nature of the service that is provided at any given CIU 400 must be preidentified and prestored in memory in the HIU 301 that is utilized as the telephony network interface, so as to enable provision of the selected service upon demand. In response to a request for service either originating with a subscriber at a selected CIU, or a request for incoming service to a subscriber originating externally to the network, status signals such as the subscriber going off hook, or a ringing condition on an incoming line, the system causes the selection and allocation of appropriate bandwidth, DS0 channels, reverse channels, carriers, etc., required to provide the selectably variable bandwidth commensurate with the selected service.

Detailed Description Paragraph Right (79):
Still referring to FIG. 12, the line cards 98', whether one or many, are preferably connected to a backplane 412 in the CIU so that signals from the various line cards may be coupled to appropriate modulators and demodulators and receive control signals from the CPU 410. The preferred backplane 412 includes a 4.096 Mbps serial digital bus that is operative to transmit 64 kbps data in a TDMA manner from a selected CODEC 407 in a selected line card to a selected reverse channel modulator 415. There is also provided a second 4.096 Mbps digital bus for transmitting data from a forward channel demodulator 420 to selected CODEC 407 in a selected line card for outgoing transmissions. The CPU 410 is operative to control the selection of line cards, reverse channel modulators, and forward channel demodulators. While the preferred embodiment illustrates the use of two 4.096 Mbps digital busses in parallel, it will be understood and appreciated to those skilled in the art that a single 8.192 Mbps digital bus could also be used.

Detailed Description Paragraph Right (82):
Incoming data from the broadband network is derived from at least one forward channel demodulator 420, which is operative to monitor a preassigned channel in the QPR-modulated forward channel utilized for incoming telephony signals. The preferred forward demodulator 420 operates in the manner described above to demodulate a QPR modulated forward channel signal in the designated telephony downstream subband of 15.840 MHz, and to monitor the directory channel and signaling channels provided as a part of the overhead data.

Detailed Description Paragraph Right (83):
It will be noted that a plurality of reverse channel modulators 415a . . . 415n may be required to provide the appropriate bandwidth required for a given level of service. For example, if a selected service entails the equivalent of four DS0's, then there is the need for four reverse channel modulators 415. Furthermore, it will be recalled that each modulator 415 is frequency agile and is not necessarily operating at a given fixed upstream carrier frequency, since upstream channels can be reassigned dynamically and in response to changing conditions such as noise level and reallocation of bandwidth in response to the subscriber's needs.

Detailed Description Paragraph Right (88):
FIG. 13 illustrates a frequency agile reverse channel modulator 415 constructed in accordance with the alternative embodiment of the present invention. The reverse channel modulator 415 is operative to receive serial data input from the digital bus in a CIU in the form of two DS0's at 64 kbps, respond to controls signal from the CPU 410 (address and control unit), and modulate the incoming data into a selected channel in QPSK for coupling to the reverse channel frequency spectrum. The modulator is operative to provide the QPSK in a selected 108 kHz subband, at a selected carrier frequency.

Detailed Description Paragraph Right (91):

The Nyquist filter 473 shapes the modulated spectrum so that it will fit in the 108 kHz occupied bandwidth with zero intersymbol interference. As a byproduct of the filter, gain control of 25 dB is obtained.

Detailed Description Paragraph Right (95):
The tunable PLL 494 receives its signal indicating the selected carrier frequency for the selected upstream channel UP1, UP2, etc. via a CONTROL/FREQ REF signal from the controller 470. As it has been described, the controller 470 receives the designated frequency for operation of the reverse modulator from a control signal received by monitoring the directory channel.

Detailed Description Paragraph Right (97):
FIG. 14 illustrates a frequency agile reverse channel demodulator converter 114' utilized in the HIU shown in FIG. 11. It will be understood that one of the reverse channel demodulator converters 114' is provided for each pair of DS0 signals provided in one of the upstream channels UP1, UP2 . . . UP194 as shown in FIG. 3C. The reverse channel demodulator converters 114', like their reverse channel modulator counterparts in the CIU, are frequency agile and can be selectively tuned to predetermined carrier frequencies in the telephony upstream bandwidth of 5-30 MHz range. The embodiment shown in FIG. 14 is preferably operative between 5.12 MHz and 49.9 MHz so as to allow for future expansion or utilization of the reverse channel bandwidth up to about 50 MHz, which would allow additional reverse channel capacity beyond the 388 DS0's of the described embodiment.

Detailed Description Paragraph Right (98):
Each reverse channel demodulator converter 114' receives an RF input signal and provides it to an upconverter or mixer 520 where the incoming signal is beat with a selectively variable frequency between 80 and 124.8 MHz, that varies in increments of 128 kHz. The 80-124.8 MHz beat signal is derived from a phase lock loop circuit 522 which is preferably a type MC145170 manufactured by Motorola. The PLL 522 varies its output frequency as a function of a CONTROL signal provided from the headend unit (HIU) 301. The PLL locks to a 128 kHz signal fed from a divide-by-32 (.div.32) circuit 525, which is driven by a 4.096 MHz clock. The CONTROL signal from the HIU that is indicative of the frequency to which the circuit is tuned is provided on the signaling channel provided from the CPU 308 (FIG. 11). This signal varies from N=625 to 975, corresponding to output frequencies of 80.0 to 124.8 MHz.

Detailed Description Paragraph Right (100):
The reference frequency 4 kHz is first multiplied up to 220 kHz by PLL 528 in order to more easily attenuate unwanted spectral byproducts from the output of PLL 530. Unwanted reference frequency sidebands are therefore more easily filtered out since the reference frequency 220 kHz is more widely separated from the PLL 530's loop bandwidth (approximately 120 Hz) than it would be if the 4 kHz reference was used directly.

Detailed Description Paragraph Right (101):
Referring back to the mixer 520, its output, which varies between 80 MHz and 124.8 MHz, is filtered through a bandpass filter 532 having a passband of approximately 3 MHz and centered at 74.88 MHz. The output of the bandpass filter 532 is provided to a mixer or downconverter 535. The downconverter beats the filtered input signal with the 85.58 MHz from the PLL 530. The output of the downconverter 535 is a 10.7 MHz signal that is band pass filtered by an output band pass filter 538, whose output is a 10.7 MHz carrier QPSK modulated signal that has been retrieved from a selected 128 kHz subband within the 5-30 MHz reverse frequency range.

Detailed Description Paragraph Right (103):
It will be noted that the frequencies selected by the PLL 522 between 80-124.8 MHz is chosen such that the output signal at 74.88 MHz is the selected signal containing the desired telephony signal in the particular selected reverse channel subband 128 kHz wide.

Detailed Description Paragraph Right (104):
Turn next to FIG. 15 for a discussion of the manner in which varying levels of the service are provided to a subscriber commensurate with a selected level of service and allocation of appropriate commensurate bandwidth to effect the service. The information illustrated in FIG. 15 is stored in the CPU 308 in the headend interface unit (HIU) 301 illustrated in FIG. 11. The CPU 308 stores in its memory a data table that correlates various information, e.g. the frequency of the upstream channel assigned to particular subscriber at a given instant in time, subscriber identification information, service level information, telco line DS0 identifying information (i.e. the identity of the

lines in the multiplexed input telephony signal provided from the telephone operating company), signaling status information, error count and threshold information indicative of noise level on a selected channel, and a "noisy channel" flag indicative of whether the noise in a selected channel has exceeded a predetermined threshold and therefore requires a change.

Detailed Description Paragraph Right (105):
The table of FIG. 15 will be described in connection with examples of varying levels of service that may be elected by a subscriber. It will be recalled that each upstream (128 kHz) channel carries two DS0 signals at 64 kbps each, QPSK modulated. Thus, the first upstream channel UP1 has a nominal carrier center frequency of 5.12 MHz, assuming that the subband for the channel begins exactly at 5.064 MHz and extends to 5.192 MHz. In the first example of a channel UP1, a subscriber identified as S1 has elected a default level of service, indicating one line of voice grade telephony service at 64 kbps. The table indicates that the telephone company (telco) DS0 line is DS0-6, which indicates that line DS0-6 in the input multiplex is the appropriate input/output line carrying communications for this subscriber at this particular instant in time. It will be appreciated that the telco DS0 number can be associated with any particular channel, because of the frequency agility of the reverse channel circuitry described herein.

Detailed Description Paragraph Right (113):
In this regard, consider the subscriber S6, who has also elected security monitoring service level. The signaling status indicates an alarm condition, and a telco line identified as DS0-191 has been assigned to this particular channel for monitoring of any signals that may be provided from the customer's security alarm network. The security monitoring signals are provided upstream to the HIU and thence via the DS0-191 line to a security service (e.g. for dispatch of an armed guard or for remote monitoring of the situation via data communicated through the system). Accordingly, it will be appreciated the bandwidth associated with security monitoring is not necessarily allocated until an alarm condition occurs, and that the bandwidth for upstream communications need only be utilized in response to an alarm condition.

Detailed Description Paragraph Right (117):
From the foregoing, it will be understood and appreciated that the frequency agile CIU is operative for modulating telephony and other signals from a subscriber in a plurality of frequency subbands in the upstream band of a broadband subscription network so as to provide selectably variable bandwidth in the upstream band commensurate with a selected subscriber communication feature such as single voice line, multiple voice lines, ISDN, security monitoring services, and the like. In the preferred embodiment, the bandwidth is selectably allocated in discrete unit of DS0's, which will be understood can be combined to provide for higher capacity digital data channels in response to varying needs of subscribers.

Detailed Description Paragraph Right (118):
Furthermore, it will be understood that the frequency agile CIU is operative to reassign signals in a selected subband, such as UP1 . . . UPn, to another subband at another frequency in response to a determination that the noise level in a particular selected subband exceeds a predetermined level.

Detailed Description Paragraph Right (119):
Finally, there is provided one upstream data link for each carrier that is utilized by the CIU 400 to provide a general purpose data transport for alarm conditions, configuration information, etc. Each CIU 400 is normally assigned at least one upstream frequency (either the DS0-1 or the DS0-2 of the 128 kHz channel), which comprises a portion of the 1.333 kbps data channel that is combined with two 64 kbps data channels to form 72 kbps for each upstream frequency subband. The 1.333 kbps data link carries the subscriber's address as well as status information associated with a subscriber's address.

Detailed Description Paragraph Right (121):
FIG. 16 is a flow chart illustrating a sequence of operations wherein a calling subscriber initiates a communication and a request for telephony, and the equipment responds by allocating bandwidth and designating an upstream channel, broadcasting the identity of a selected channel in a downstream directory channel for receipt by the requesting CIU, measurement of signal quality in the channel, etc.

Detailed Description Paragraph Right (125):
At step 612, a CRC computation associated with the subframes and superframes is computed and added in the appropriate fields within the frame and subframe. At step

615, the superframe is provided to the QPSK modulator, where it is transmitted on the broadband network upstream on the designated subband for upstream communications.

Detailed Description Paragraph Right (130):
FIG. 17 illustrates the preferred method of dynamic bandwidth allocation in response to selected levels of service requested by subscribers. There are two pathways for invoking the method involved with dynamic bandwidth allocation on behalf of a customer: (1) when a calling subscriber initiates a request for telephony service originating at CIU, and (2) when an incoming call is received for a subscriber on a particular incoming telco DS0 line from the telephony network. Both pathways require that the system determine the appropriate level of service, and commensurate bandwidth, for the call. These steps are shown at 701 and 702, respectively. It will be appreciated that the remaining steps are substantially the same regardless of whether the subscriber initiates a call or an incoming call is received for the subscriber.

Detailed Description Paragraph Right (137):
Finally, at step 720, selected reverse channel frequencies are transmitted to the particular subscriber in the forward directory channel, by transmitting the CIU address and upstream channel identification. The identity of the forward channel DS0 is also identified in the service level table for incoming signals in the forward directory channel so that incoming signals from the telephony network can be routed to an appropriate forward channel frequency and DS0 channel for provision to the subscriber CIU, which monitors the appropriate DS0 channel in the forward spectrum. In this manner, it will be understood and appreciated that bandwidth may be allocated in a selectably variable manner so as to provide for appropriate levels of service that have been selected by a customer.

Detailed Description Paragraph Right (143):
As discussed above, one of the difficulties of implementing a commercially viable broadband telephony system is the problem of limited bandwidth, particularly in the reverse direction. Specifically, there are far fewer communications channels available in the reverse portions of the frequency spectrum than is necessary to accommodate all of the potential subscribers to the telephony system at the same time. One commonly used technique of lessening the effect of limited bandwidth in the reverse path is to configure the cable system in an FTSA architecture. In the FTSA configuration, as previously described, the subscriber base is divided into smaller groups of subscribers, called serving areas, which allows for the reuse of limited reverse band frequency ranges. Reuse is possible because each service area only serves a limited number of subscribers, so that use of a particular upstream communication channel (or frequency) in one serving area does not interfere with use of the same channel (or frequency) in a geographically separate serving area.

Detailed Description Paragraph Right (160):
The above-described structure defines a subframe with three repetitions of 26 bytes plus two FAS and two DIR for a total of 82 bytes, or 656 bits per 125 .mu.s subframe. The preferred data rate is 5.248 Mbps which maps to a QPR RF bandwidth of 2.624 MHz. Such an RF spectrum allows for placing carders on 3 MHz spacing.

Detailed Description Paragraph Right (164):
Because the preferred embodiment contemplates that multiple subscribers or CIUs may share reverse communications channels, it is important for the telephony system to provide a scheme for allocating the reverse path bandwidth to the CIUs and for resolving the contention that arises when more than one subscriber. or CIU, attempts to simultaneously communicate on the same reverse channel. FIG. 19 illustrates the reverse path allocation and contention resolution scheme implemented according to the preferred embodiment of the present invention. FIG. 19 represents computer-implemented steps carried out by the program running on the CPU 410.

Detailed Description Paragraph Right (177):
It will also be appreciated that the method and system described above for changing the reverse channel assignment in the event of noise, interference, etc. is also operative in connection with the described reverse path allocation and contention resolution scheme. It will be recalled that the modulators of the CIUs are frequency agile and may be dynamically reassigned to another selected subband, such as UP1 . . . UPn, at another frequency in response to a determination that the noise level in a particular selected subband exceeds a predetermined level.

Detailed Description Paragraph Right (178):
The steps described above in connection with FIG. 16 are applicable in this regard. In

the event that excessive noise is detected in the selected reverse channel, the frequency subband may be reassigned in the manner described to another, hopefully less noisy channel. This entails first determining a reverse channel that is presently inactive, reassigning all subscribers that are presently assigned to that inactive channel, assigning the subscriber experiencing noise problems to that channel, and retransmitting the modified reverse channel assignments in the downstream directory channel. The frequency agile modulators in the CIUs respond by changing to the newly assigned reverse channel frequencies.

Detailed Description Paragraph Left (1):
Alternative Embodiment--Selectable Bandwidth Allocation

CLAIMS:

1. A telephony system for communicating telephony signals between a telephony network and a broadband communication network including a headend communicating to a plurality of subscribers, comprising:

a modulator, coupled between the telephony network and the headend, for modulating the telephony signals from the telephony network on a carrier in a first band of the broadband communication network;

more than one subscriber terminal with a frequency agile modulator for modulating telephony signals from the subscriber in a selected frequency subband in a second band of the broadband network for communication to the headend;

equipment for assigning a plurality of subscribers to a selected frequency subband in the second band of a subscription network;

reverse path contention resolution equipment for detecting contention by more than one subscriber for the selected frequency subband and reassigning at least one subscriber to a different frequency subband in the second band; and

a demodulator, coupled between the telephony network and the headend, for demodulating the telephony signals in the selected frequency subband and coupling them to the telephony network.

3. The system of claim 2, further comprising:

a noise monitor for monitoring the noise level in a selected frequency subband associated with a particular subscriber, and

equipment responsive to the noise monitor for communicating a frequency change signal to said particular subscriber when the noise level in the selected frequency subband exceeds a predetermined threshold,

whereby the subscriber terminal changes the frequency for communicating at least some of the telephony signals to a different selected frequency subband when a given channel becomes too noisy.

5. The system of claim 1 wherein the assigning equipment comprises:

equipment for communicating a channel assignment message containing subscriber identification information and the identity of one or more selected frequency subbands in the second band associated with the subscriber identification information.

7. The system of claim 1, wherein the frequency agile modulator is operative to change the frequency at which telephony signals are being communicated to the headend from a first frequency subband to a second frequency subband in response to a command received from the headend.

10. The system of claim 8, wherein each 128 kHz channel comprises a 108 kHz bandwidth data channel and 20 kHz in guard bands.

15. The system of claim 1, wherein a subscriber terminal is operative, in response to an outgoing call by a subscriber associated with the terminal, to begin transmitting signals in the selected frequency subband assigned by the assigning equipment as an initial transmission; and

in response to failure to receive an acknowledge signal from the headend within a predetermined time period after said initial transmission, to cease transmitting signals in the selected frequency subband.

16. The system of claim 15, wherein the headend in responsive to said initial transmission from a particular subscriber for reassigning all other subscribers assigned to the selected frequency subband to a different frequency subband in the second band.

17. The system of claim 15, wherein the headend is operative for changing the frequency of a selected subscriber from the selected frequency subband in the second frequency band on the broadband communication network to another frequency subband during a communication session.

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L7: Entry 33 of 38 File: USPT Feb 3, 1998

DOCUMENT-IDENTIFIER: US 5715242 A
TITLE: System for integrated distribution of switched voice and television on coaxial cable with phase distortion correction

Brief Summary Paragraph Right (6):
As a result of this limited voice channel capacity, the FPN system is not readily useable where large scale voice distribution is desired. Moreover, since there is no mechanism in the FPN system for permitting voice channels assigned to one RF channel pair to be able to communicate with voice channels assigned to another RF pair, increased capacity cannot be realized merely by allocating additional RF channels to voice distribution. In any case, such allocation would reduce the number of allowable video channels and provide only a limited number of additional voice channels per RF channel pair. Finally, the FPN system requires equipment at each subscriber location to process the extensive control information carried in the associated voice channel. This increases the complexity and cost of the equipment.

Brief Summary Paragraph Right (11):
Phase distortion occurs because the signals from the different subscriber locations experience different amounts of delay in propagating from each location to the central switch which is located at the so-called head end of the system. As above-noted, the modulator/demodulator at the central switch demodulates all RF transmitting signals to remove the network carrier. This is accomplished using a locally generated network carrier.

Brief Summary Paragraph Right (15):
One known technique for providing correction of phase distortion in a frequency-division-multiplexed system is found in a system designed by Securicor PMR Systems Limited for mobile radio technology. The Securicor system uses a pilot tone and linear modulation to reduce phase discrepancies in voice band transmission. In particular, each voice band channel is split into high and low sub-bands and the high band shifted up in frequency to leave a gap into which a pilot tone is inserted.

Detailed Description Paragraph Right (4):
In the present case, the broadband coaxial network 2 is of the type typically used to distribute video signals and, thus, has a broad bandwidth reaching as high as about 900 MHz. Furthermore, to permit concurrent distribution of multiple video signals on the network, the 900 MHz bandwidth of the network is divided into multiple, contiguous broadband RF channels, each individual broadband RF channel being of sufficient bandwidth to carry an independent video signal. To accommodate standard video signals, each broadband RF channel would thus be approximately 6 MHz wide.

Detailed Description Paragraph Right (5):
The VSB demodulator/modulator 206 is located at the head end of the system and receives input video signals 208A-208X from video or TV sources 207A-207X. Each video source 207A-207X might be an antenna or a satellite. The VSB demodulator/modulator 206 modulates the input video signals onto a network carrier so that the resultant network signal contains contiguous or multiplexed broadband RF channels each carrying one of the video signals. This network signal is placed on the downstream coaxial cable 202 and subsequently received and decoded by the televisions 600A-600Y located at the subscriber locations 7A-7Y.

Detailed Description Paragraph Right (7):
More particularly, a number of broadband RF (i.e., 6 MHz) channels of the cable network 2 are used to carry voice and data information and associated signalling and control information among the subscriber locations. This is accomplished by adapting the system

1 for each subscriber location to establish associated RF transmitting and RF receiving voice channels and by allocating these voice channels to one or more of the broadband RF channels being used for voice and data transmission. It is further accomplished by adapting the system 1 to provide central switching and control of the RF transmitting and receiving voice channels such that each RF transmitting voice channel can be selectively switched or coupled to any one of the RF receiving voice channels. In this way, a voice path can be established between each subscriber location and any of the other subscriber locations in the system.

Detailed Description Paragraph Right (13):
More particularly, after demodulation of the upstream network signal to produce the individual RF broadband channels, the modulator/demodulator 206 passes the broadband channels to respective output ports 210A to 210M connected to converter units 4A-4M, respectively. Each converter unit then converts the RF transmitting voice channels in its received RF broadband channel into corresponding digital voice channels and one or more control channels organized into one or more TDM signals for processing by the digital switch 3.

Detailed Description Paragraph Right (14):
As a result of its processing, the digital switch 3 places voice, data and signalling information into digital voice channels and one or more control channels which correspond to the receiving RF voice channels. The switch 3 organizes these digital voice channels and control channels also into one or more TDM signals and conveys these signals to their associated converters 4A to 4M, i.e., to the respective converters assigned to the RF broadband channel carrying the corresponding RF voice channels. Each converter then converts its received digital channels into a corresponding FDM RF receiving voice channel group. Each receiving voice channel group is then delivered to the modulator/demodulator 206 where it is placed in the corresponding broadband RF channel and modulated onto the network carrier for subsequent delivery to the subscriber locations via the downstream cable 202.

Detailed Description Paragraph Right (15):
In the present illustrative case of the use of TDM switch 302 in the digital switch 3, the digital voice channels transmitted between the switch and each of the converters 4A to 4M are contained in time slots of the generated TDM signals. Each time division multiplexed signal contains a number of digital voice channels, a synchronization channel and a control channel for control and signalling information.

Detailed Description Paragraph Right (17):
Each of the TRANSMUXES in the units 4A to 4M converts its received digital voice channels and its received synchronization and control channels into a corresponding FDM sub-group of RF receiving voice channels. Each FDM channel sub-group is then combined by a demultiplexer/multiplexer (DEMUX/MUX) unit in the respective converter (e.g., DEMUX/MUX 400A in converter 4A) with other channel sub-groups to generate an FDM RF channel group which is delivered to a respective receive port 209A to 209M on the modulator/demodulator 206.

Detailed Description Paragraph Right (18):
In the other direction, the reverse process occurs in each of the converter units 4A to 4M. Thus, the FDM RF transmitting voice channel group received at each converter 4A to 4M is separated by the DEMUX/MUX into FDM sub-groups of RF transmit voice channels. These FDM sub-groups are then fed to respective TRANSMUXES, where they are converted to TDM transmit signals having corresponding digital transmit voice channels and associated synchronization and control channels. These TDM signals are delivered to corresponding DTUs and processing by the TDM switch 302.

Detailed Description Paragraph Right (19):
FIGS. 2A and 2B show the format of the TDM signals transmitted between the DTUs 301A and 302A and the TRANSMUX 401A of the converter unit 4A. Each signal is shown as carrying 30 digital voice channels (T1-T15 and T17-T32), one synchronization channel (TO) and one control channel (T16), the two signals together accounting for 60 voice channels.

Detailed Description Paragraph Right (20):
FIG. 3 illustrates the FDM RF receiving voice channel sub-group signal transmitted between the TRANSMUX 401A and DEMUX/MUX 400A of the unit 4A. This signal results from frequency conversion of the TDM signals of FIGS. 2A and 2B. As shown, each digital voice channel is converted into a 4 KHz wide RF voice channel, resulting in 60 RF voice channels, each containing the voice, control and synchronization information pertaining

to its associated digital channels.

Detailed Description Paragraph Right (23):
As above-indicated, the RF transmitting and receiving voice channels are coupled to and from their corresponding subscriber locations via respective dropboxes 5A to 5Y. Referring to dropbox 5A for illustrative purposes, the dropbox comprises a VSB modulator/demodulator or modem 502A, a single channel multiplexer 501A, and an interface unit 500A. The VSB modem 502A has a receiving port 504A which connects to the downstream cable 202 at drop 211A and a transmitting port 503A which connects to the upstream cable 201 at drop 212A.

Detailed Description Paragraph Right (24):
The VSB modem 502A is configured to demodulate or extract from the downstream network signal the broadband RF channel (i.e., 6 MHz channel) containing the RF receiving voice channel associated with the subscriber location 7A. Thus, assuming the subscriber location 7A corresponds to the RF receiving voice channel 1 in the network signal of FIG. 5A, the modem 502A will extract from this signal the first broadband RF channel (i.e, the 360-366 MHz channel), since it contains the RF receiving voice channel 1. Conversely, an RF transmitting voice channel i sent by the single channel multiplexer 501A to the VSB modem 502A will be modulated by the VSB modem 502A into the first broadband RF channel and then transmitted from port 503A of the modem to the upstream cable 201.

Detailed Description Paragraph Right (25):
The first broadband RF voice channel (366--366 MHz) once extracted by the modem 502A, is then conveyed to the single channel multiplexer 501A which is configured to demodulate the RF channel group to obtain the associated RF receiving voice channel (channel 1) and return this channel to base band to recover the resultant 4 KHz baseband receiving channel. This channel is then processed to extract voice information (i.e., band limited to 300-3400 Hz) and also processed to extract any out-of-band signalling information. The voice information is then passed via output port 507A to an input port 505A of an interface unit 500A. The signalling information is, in turn, passed via another output port Mm to a further input port Ei of the interface unit.

Detailed Description Paragraph Right (26):
In the transmit direction, the single channel multiplexer 501A receives at its input port 508A from the output port 506A of the interface unit 500A, baseband voice information. The multiplexer also receives signalling information at its Em port from the Mi port of the interface unit. This voice and signalling information is, in turn, modulated by the multiplexer into the RF transmitting voice channel (i.e., channel 1) and sent by the multiplexer to the modem 502A where it is placed in the first RF broadband channel of the network 2, as above-described.

Detailed Description Paragraph Right (28):
The interface unit 500A also develops signalling information based upon the signalling information received at its Ei port and the state of the phone 601A. This signalling information is passed from the Mi port of the interface to the Em port of the modem where it is included in the RF transmitting voice channel developed by the modem, as above-described.

Detailed Description Paragraph Right (32):
FIG. 7 shows in greater detail the VSB modem 502A and the single channel multiplexer 501A shown in FIG. 1 modified to utilize the pilot signal generated at the DEMUX/MUX for synchronization. The network signal received at the VSB modem input port 504A is supplied to a carrier bandpass filter 802 and, after passage to VSB demodulator 800, to a pilot bandpass filter 803. The network carrier bandpass filter 802 recovers the 361.25 MHz network carrier, while the pilot bandpass filter 803 recovers the 308 Khz pilot signal. The recovered signals are then used in the modulator and demodulator processing to ensure synchronization.

Detailed Description Paragraph Right (33):
More particularly, the recovered network carrier is applied to the VSB modulator 807 of the VSB MODEM 502, thereby ensuring that modulation occurs at the appropriate frequency. The 308 KHz pilot signal, in turn, is applied to a divide by 77 frequency divider 804 to recover the 4 Khz reference signal. This signal is then applied to a preset multiplier 805 to derive the reference frequency for the associated RF transmit and receive voice channels of the subscriber location (i.e., the frequency 312 Khz for the channel 1 of the location 7A). This reference frequency is then applied to the SSB Modulator 806 and the SSB Demodulator 801A of the multiplexer to provide the RF

transmit voice channel and recover the baseband voice channel, respectively.

Detailed Description Paragraph Right (40):
Step 2: --3825 Hz ON--; The interface 500B transfers a logic signal from its Mi port to the Em port of the single channel multiplexer 501B instructing it to turn on the 3825 Hz tone generator. This causes a 3825 Hz tone to be continuously transmitted in the associated RF transmitting voice channel 2 of the network signal of the modem 502B.

Detailed Description Paragraph Right (41):
Step 3: --PHONE 601B OFF-HOOK--; The RF transmitting voice channel 2 containing the 3825 Hz tone is passed by the modulator/demodulator 206 and DEMUX/MUX 400A to the TRANSMUX 401A assigned to transmitting channel 2. The TRANSMUX detects the presence of the 3825 Hz tone and transmits an off hook signal to the TDM switch 302 via DTU 301A. This signal is carried in the control channel of the TDM signal carrying the transmit voice channel 2 and indicates to the switch that the channel 2 is off-hook.

Detailed Description Paragraph Right (42):
Step 4: --SEND DIALTONE to PHONE 601B--; The TDM switch 302 places a dial tone signal in the control channel of the TDM signal carrying the receiving voice channel 2 and it is delivered by the DTU 301A to the TRANSMUX 401A. The latter places a dial tone in the RF receiving voice channel 2 which passes via the downstream network signal to the corresponding drop box 5B. This tone is extracted by bandpass filter 810 in the multiplexer 501B and passed through the interface circuit 500B to the T and R lines of phone 601B.

Detailed Description Paragraph Right (45):
Step 6: --RING INSTRUCTION--; The TDM switch 302 sends a message in the control channel of the TDM signal containing the voice channel 1 instructing the TRANSMUX 401A to turn on a 3825 Hz tone in RF receive voice channel 1.

Detailed Description Paragraph Right (51):
Step 12 --PHONE A OFF-HOOK--; The TRANSMUX associated with transmitting RF voice channel 1 detects the presence of the 3825 Hz tone in the RF voice channel 1 and transmits an off-hook signal to the TDM switch 302 via the control channel of the TDM signal containing the transmitting voice channel 1.

Detailed Description Paragraph Right (56):
Step 17: --PHONE 601B ON-HOOK--; The TRANSMUX 901A assigned to RF voice channel 2 detects the absence of the 3825 Hz tone and transmits an on hook signal to the TDM switch 302 in the control channel of the TDM signal containing the transmit voice channel 2.

Detailed Description Paragraph Right (71):
FIG. 10 illustrates a modification of the VSB modem and single channel multiplexer shown in FIG. 7. In the case of FIG. 10, the RF transmitting and receiving channels are developed by direct modulation and demodulation, respectively. This is realized, in the case of the RF transmitting channel, by modulating the voice and signalling information directly at the frequency desired for the transmitting channel in the associated RF broadband channel. In the case of the RF receiving channel, it is realized by demodulating the received signal directly at the frequency of the RF receiving channel in its associated RF broadband channel. Furthermore, the pilot signal is recovered from the received signal in the FIG. 10 arrangement by using a VSB demodulator whose frequency band of operation need only be sufficiently wide to reach the pilot frequency as modulated onto the network carrier.

Detailed Description Paragraph Right (79):
In the system of FIGS. 1A and 1B, the VSB modems 502A-502Y used at the drop boxes 5A-5Y cause the RF transmitting channels carried by the network carrier to be vestigial sideband signals. The composite upstream signal on the line 201 thus comprises a number of vestigial sideband signals each carrying a part of the network carrier. These signals are received at the VSB modulator/demodulator 206 which, in accordance with conventional vestigial sideband principles, demodulates the signals by regenerating the network carrier from the received signals and by using the regenerated network carrier to demodulate the signals. This extracts the RF broadband channels containing the RF transmitting voice channel groups. Each RF broadband channel is then applied to the appropriate DEMUX/MUX.

Detailed Description Paragraph Right (81):
In accordance with the principles of the present invention, the system 1 is further

adapted to correct any such phase distortion in the RF transmitting and/or receiving channels, resulting from the varying phase of the regenerated network carrier. This is accomplished by modifying each subscriber location so that it generates a phase correction pilot tone having a fixed phase relationship with the corresponding RF transmitting channel at the subscriber location and so that the phase correction pilot tones of the subscriber locations occupy one or more dedicated phase correction pilot tone channels which are separate from the transmitting voice channels. It is further accomplished by modifying the equipment at the head end of the system 1 so that each phase correction pilot tone is extracted and then used to correct any phase distortion in its corresponding transmitting and/or receiving channels.

Detailed Description Paragraph Right (82):
In the present illustrative case, two of the channels in each 60 channel FDM sub-group of the RF transmitting channels are reserved or dedicated for service as the phase correction pilot tone channels. More particularly, the channels 30 and 60 in each transmitting channel FDM sub-group are used to carry the pilot tones for the transmitting channels 1-29 and 31-59, respectively, of that sub-group. Each phase correction pilot tone has a unique frequency which allows the tone to be separated using frequency selective detection equipment from the other phase correction pilot tones in its channel. Each tone, furthermore, has a fixed phase relationship with the corresponding RF receiving channel and its associated information and experiences the same phase distortion experienced by such channel and information in traveling to the head end of the system 1.

CLAIMS:

2. A system in accordance with claim 1, wherein: said central means further comprises first means for establishing for each RF transmitting channel a transmitting digital channel for carrying digital voice information corresponding to the analog voice information carried by the RF transmitting channel, for establishing one or more first digital control channels for carrying the signalling information of the RF transmitting channels and for establishing one or more digital phase correction pilot tone channels for carrying the phase correction pilot tones in the one or more phase correction pilot tone channels, said transmitting digital channels, said one or more first digital control channels and said one or more digital phase correction pilot tone channels forming one or more transmitting time-division-multiplexed signals each of which containing a number of transmitting digital channels, a first control channel carrying the signalling information for said number of transmitting digital channels and a digital phase correction pilot tone channel carrying the phase correction pilot tones for said number of transmitting digital channels, said first means including transmultiplexer means for converting said one or more transmitting frequency-division-multiplexed signals into said one or more transmitting time-division-multiplexed signals;

digital switch means for establishing for each RF receiving channel a receiving digital channel for carrying digital voice information corresponding to the analog voice information carried by the RF receiving channel and for establishing one or more second digital control channels for carrying the signalling information of the RF receiving channels, said receiving digital channels and said second digital control channels forming one or more receiving time-division-multiplexed signals each of which containing a number of receiving digital channels and a second control channel carrying the signalling information for said number of receiving digital channels, said digital switch means selectively coupling each transmitting digital channel in said one or more transmitting time-division-multiplexed signals to any of the receiving digital channels in said one or more receiving time-division-multiplexed signals;

and said transmultiplexer means of said first means converting said one or more receiving time-division-multiplexed signals to said one or more receiving frequency-division-multiplexed signals.

5. A system in accordance with claim 4, wherein:

said phase correction means includes for each transmitting time-division-multiplexed signal: a time division demultiplexer for separating the transmitting digital channels, the digital phase correction pilot tone channel and the first digital control channel in that time division multiplexed signal; a frequency selective phase detector for detecting the phase of each phase correction pilot tone in the separated digital phase correction pilot tone channel; a phase shifter for each separated transmitting digital channel for adjusting the phase of the separated transmitting digital channel based on

the detected phase of the phase correction pilot tone associated with that separated transmitting digital channel and detected by said frequency selective phase detector; and a time-division-multiplexer for multiplexing said phase adjusted transmitting digital channels and said separated first digital control channel to produce a phase adjusted transmitting time-division-multiplexed signal;

and said digital switch selectively coupling each of said phase adjusted transmitting digital channels in said one or more phase adjusted transmitting time-division-multiplexed signals to any one of the receiving digital channels in said one or more receiving time-division-multiplexed signals.

13. A method in accordance with claim 12, wherein:

said enabling by said central means further includes: establishing for each RF transmitting channel a transmitting digital channel for carrying digital voice information corresponding to the analog voice information carried by the RF transmitting channel, establishing one or more first digital control channels for carrying the signalling information of the RF transmitting channels and establishing one or more digital phase correction pilot tone channels for carrying the phase correction pilot tones in the one or more phase correction pilot tone channels, said transmitting digital channels, said one or more first digital control channels and said one or more digital phase correction pilot tone channels forming one or more transmitting time-division-multiplexed signals each of which containing a number of transmitting digital channels, a first control channel carrying the signalling information for said number of transmitting digital channels and a digital phase correction pilot tone channel carrying the phase correction pilot tones for said number of transmitting digital channels, said steps of establishing including using a transmultiplexer means for converting said one or more transmitting frequency-division-multiplexed signals into said one or more transmitting time-division-multiplexed signals; and using a digital switch means for establishing for each RF receiving channel a receiving digital channel for carrying digital voice information corresponding to the analog voice information carried by the RF receiving channel and for establishing one or more second digital control channels for carrying the signalling information of the RF receiving channels, said receiving digital channels and said second digital control channels forming one or more receiving time-division-multiplexed signals each of which containing a number of receiving digital channels and a second control channel carrying the signalling information for said number of receiving digital channels, and further using said digital switch means to selectively couple each transmitting digital channel in said one or more transmitting time-division-multiplexed signals to any of the receiving digital channels in said one or more receiving time-division-multiplexed signals; and using said transmultiplexer means of said first means to convert said one or more receiving time-division-multiplexed signals to said one or more receiving frequency-division-multiplexed signals.

16. A method in accordance with claim 15, wherein:

said step of recovering and correcting includes for each transmitting time-division-multiplexed signal: separating the transmitting digital channels, the digital phase correction pilot tone channel and the first digital control channel in that time division multiplexed signal; detecting the phase of each phase correction pilot tone in the separated digital phase correction pilot tone channel; for each separated transmitting digital channel adjusting the phase of the separated transmitting digital channel based on the detected phase of the phase correction pilot tone associated with that separated transmitting digital channel and detected in said detecting step; and multiplexing said phase adjusted transmitting digital channels and said separated first digital control channel to produce a phase adjusted transmitting time-division-multiplexed signal;

and said step of using said digital switch means includes using said digital switch means to selectively couple each of said phase adjusted transmitting digital channels in said one or more phase adjusted transmitting time-division-multiplexed signals to any one of the receiving digital channels in said one or more receiving time-division-multiplexed signals.

23. An apparatus in accordance with claim 22, wherein: said central means further comprises first means for establishing for each RF transmitting channel a transmitting digital channel for carrying digital voice information corresponding to the analog voice information carried by the RF transmitting channel, for establishing one or more

first digital control channels for carrying the signalling information of the RF transmitting channels and for establishing one or more digital phase correction pilot tone channels for carrying the phase correction pilot tones in the one or more phase correction pilot tone channels, said transmitting digital channels, said one or more first digital control channels and said one or more digital phase correction pilot tone channels forming one or more transmitting time-division-multiplexed signals each of which containing a number of transmitting digital channels, a first control channel carrying the signalling information for said number of transmitting digital channels and a digital phase correction pilot tone channel carrying the phase correction pilot tones for said number of transmitting digital channels, said first means including transmultiplexer means for converting said one or more transmitting frequency-division-multiplexed signals into said one or more transmitting time-division-multiplexed signals;

digital switch means for establishing for each RF receiving channel a receiving digital channel for carrying digital voice information corresponding to the analog voice information carried by the RF receiving channel and for establishing one or more second digital control channels for carrying the signalling information of the RF receiving channels, said receiving digital channels and said second digital control channels forming one or more receiving time-division-multiplexed signals each of which containing a number of receiving digital channels and a second control channel carrying the signalling information for said number of receiving digital channels, said digital switch means selectively coupling each transmitting digital channel in said one or more transmitting time-division-multiplexed signals to any of the receiving digital channels in said one or more receiving time-division-multiplexed signals;

and said transmultiplexer means of said first means converting said one or more receiving time-division-multiplexed signals to said one or more receiving frequency-division-multiplexed signals.

26. An apparatus in accordance with claim 25, wherein:

said phase correction means includes for each transmitting time-division-multiplexed signal: a time division demultiplexer for separating the transmitting digital channels, the digital phase correction pilot tone channel and the first digital control channel in that time division-multiplexed-signal; a frequency selective phase detector for detecting the phase of each phase correction pilot tone in the separated digital phase correction pilot tone channel; a phase shifter for each separated transmitting digital channel for adjusting the phase of the separated transmitting digital channel based on the detected phase of the phase correction pilot tone associated with that separated transmitting digital channel and detected by said frequency selective phase detector; and a time-division-multiplexer for multiplexing said phase adjusted transmitting digital channels and said separated first digital control channel to produce a phase adjusted transmitting time-division-multiplexed signal;

and said digital switch selectively coupling each of said phase adjusted transmitting digital channels in said one or more phase adjusted transmitting time-division-multiplexed signals to any one of the receiving digital channels in said one or more receiving time-division-multiplexed signals.

Similarly, as illustrated in the marker channel MC.sub.2, the first, second and third transforms V.sub.B1 [.phi..sub.B1 ], V.sub.B2 [.phi..sub.B2 ], and V.sub.B3 [.phi..sub.B3 ] of the signal V.sub.1B are selected, in the sub-band 903, thus reducing equation (24) to:

Detailed Description Paragraph Right (232):
Considering now the signal V.sub.2 in connection with sub-bands 904, 905 and 906 it is processed similarly to the signal V.sub.1, and it could be expressed by the following equation:

Detailed Description Paragraph Right (233):
In a similar way, the selective compression of the video signal V.sub.3 is illustrated in sub-bands 907, 908 and 909 as follows:

Detailed Description Paragraph Right (238):
FIG. 34 shows the six illustrative VAD marker channels MC.sub.1 through MC.sub.6 of FIG. 30, with a further breakdown of the sub-bands 901 through 906. These marker channels are useful visual aid techniques to simplify the description of the various compression schemes according to the present invention, and to aid in the design of the PDS and its maintenance.

Detailed Description Paragraph Right (239):
Each of the sub-bands, such as the sub-band 901, includes five consecutive intervals, which are illustrated as boxes, in order to facilitate the understanding of the invention. Each of these intervals indicates the number or order of the harmonic component selected to be processed. In the present example, it is desired to process only the first five harmonic components, and therefore, only five intervals have been selected. It should however be understood that the number of intervals (five) is shown for illustrative purposes and is not intended to be limiting, and other numbers could be employed without departing from the spirit of the invention. In operation, the sub-bands may be programmed independently from each other, and the programming process could be continuously monitored and updated according to the signals being processed.

Detailed Description Paragraph Right (240):
FIGS. 35 and 36 illustrate a compression scheme, whereby the signals in the sub-bands 901, 902 and 903 are serially multiplexed. The harmonic frequencies allocation is as follows:

Detailed Description Paragraph Right (242):
With either the above exemplary compression schemes, harmonic frequencies and sub-bands are now freed to be allocated to other signals, possibly non video signals.

Detailed Description Paragraph Right (260):
The marker channel MC.sub.3, indicates that the CVSE 989 has assigned the harmonic component V.sub.R3 [.phi..sub.R3 ] in sub-band 901. The harmonic component V.sub.G2 [.phi..sub.G2 ] has been assigned in sub-band 902, but no harmonic components were assigned in the video sub-band 903. It should be re-emphasized at this point that there is no intention to limit the marker channel architecture to the R,G and B frequencies, and that other appropriate frequencies (i.e. video frequencies) could alternatively be selected. Furthermore, the selection and assignment of the sub-bands to the audio and data channels could be done automatically, by setting a hierarchical order for each audio channel. For instance, the third and fourth harmonic components V.sub.G3 [.phi..sub.G3 ] and V.sub.G4 [.phi..sub.G4 ] in the sub-band 902 have been assigned to the audio channel AC.sub.P, while the harmonic component V.sub.G2 [.phi..sub.G2 ], also in the sub-band 902, is assigned to the audio channel AC.sub.1. By varying the assignment combination of the harmonic components, it is now possible to arrive to various combinations of audio, data and video signals.

Detailed Description Paragraph Right (261):
The data channels DC.sub.1 through DC.sub.Q are modulated over video frequencies in a similar manner as described above in connection with the audio channels, and sub-bands assignment is carried out based on priority and availability. The video signals, video-modulated audio signals and/or video-modulated data signals are then multiplexed as video signals V.sub.10 (FIG. 29), and transmitted to the ground station GS.sub.4.

Detailed Description Paragraph Right (262):
In certain instances, it would be desirable to assign predetermined harmonic components to a signal, such as an audio or video signal. However, it is possible that a conflict or a frequency assignment competition may arise in that those harmonic components have

already been pre-assigned in the sub-band in question. In anticipation of this situation, the CVSE 989 "slides" the signal and then reassigns another sub-band. It is also possible to leave unassigned certain sub-bands along the marker channels, such that these sub-bands will be reassigned, at will, possibly automatically, in the event of harmonic frequency competition. This feature is referred to as "sub-band re-assignment".

Detailed Description Paragraph Right (263):
Another feature anticipated by the present invention is the "sub-band anti-competition", which allocates a predetermined priority to a signal which has been reassigned. For instance, as we mentioned above, audio signals takes precedence over data signals. However, a data signal could be programmed to take precedence over a reassigned audio signal.

Detailed Description Paragraph Right (267):
Widen the video, audio and/or data signals are selected for retrieval and decoding, these signals are demultiplexed into separate video channels, and then demultiplexed once again into different video bands. The demultiplexed video bands are separated into video sub-bands which contain the harmonic components.

Detailed Description Paragraph Right (269):
Considering for purposes of illustration marker channel MC.sub.3, which is the marker channel for the audio channel AC.sub.1, the digit "1" in the third box or register of sub-band 901 indicates that the audio signals have been modulated over the third Fourier harmonic (R) frequency. Consequently, when the VAD signals are to be reconstructed, the scheme 1025 is used to select only those harmonic frequencies that need to be processed, and to disregard the other harmonic frequencies.

Detailed Description Paragraph Right (270):
This selection process of the harmonic frequencies is made clearer when further explained in conjunction with the VAD marker channel 1027 of FIG. 38. The VAD marker channel or data encoding and display channel 1027 combines the information in the marker channels of FIG. 30, and illustrates, in a visual manner, the information encoded in the sub-bands.

Detailed Description Paragraph Right (271):
Considering for example the sub-band 901 of the VAD marker channel 1027, this sub-band has been allocated and divided into five registers, each of which is dedicated to a particular harmonic R video harmonic frequency. The first two registers indicate that the first two harmonic frequencies have been assigned to video signals from the video channel VC.sub.1, and that video signals have actually been transmitted or received. The following register indicates that the third R video harmonic frequency has been assigned to an audio signal from the first audio channel AC.sub.1. The last two registers show that the fourth and fifth R harmonic frequencies have been assigned to data signals from the data channel DC.sub.1 and DC.sub.Q respectively. While only five registers have been selected for the marker channels illustrated and described in the present specification, it should be understood to those skilled in the art that other numbers of registers could be selected depending on the nature of the application.

Detailed Description Paragraph Right (272):
FIG. 38 is a tabular representation of the VAD mapping system 1030 which registers and stores the data in the marker channels of FIG. 38. The table of FIG. 38 indicates that sub-band 901 is composed of video, audio and data signals; that the video signals have been assigned the first and second Fourier harmonic frequencies; that the audio signals have been modulated over the third Fourier harmonic frequency; and that the data signals have been modulated over the fourth and fifth Fourier harmonic frequencies. It would be possible to assign additional coordinates to the information in the registers of the VAD mapping system, which includes the magnitude or amplitude of the stored signal, as well as its source, such as the designation of the video, audio or data channel number.

Detailed Description Paragraph Right (302):
The transmission station 204A includes a computer 53 which is the central control unit for the signal samplers 206, 208, 210; the compressors 216, 218, 220; the multiplexer 222; the storage unit 242; and the selectors 275 and 275A. In the preferred embodiment, the selector 275 is used to control the multiplexing and transmission of selected channels, while the selector 275A is used to control the initial reception of incoming channels (1 through n). Thus, if the computer 53, determines that only a certain number of channels (i.e. 1 and 2) have been selected, via the selectors 275 and 275A, then it

can either disable the operation of the non functional samplers (i.e. 210); or, in the alternative, it could use them to assist in alleviating the traffic on congested circuits. In this manner, the operation of the transmission station 204A is optimized.

Detailed Description Paragraph Right (334):
The present invention also relates to various recording and storage media, such as optical discs, floppy discs, compact discs; cassettes of different sizes, i.e. micro or mini cassettes; etc.m digital modems and facsimile machines, which utilize the foregoing compression and multiplexing methods. Basically, the audio and/or data signals are modulated over video frequencies, modulated and stored as video signals. The video signals could be generated by television monitors, ultrasound scanners, scanners, printers, facsimile machines or other devices capable of producing a raster scan.

Detailed Description Paragraph Right (337):
A conventional digital modem is described in the Motley et al U.S. Pat. No. 3,906,347, which is incorporated herein by reference. The Motley patent includes three sets of claims. The first set includes claims 1 through 4 and relates to a transversal equalizer; the second set includes claims 5 through 10 and relates to an equalization network; and the third set includes claims 11 and 12 which also relates to an equalization network.

Detailed Description Paragraph Right (338):
FIGS. 48 through 52C illustrate a data transmission system 3001 according to the present invention. The data transmission system 3001 uses a similar transmission principle to that of the modem in the Motley et al. patent, with some exceptions in the design, including the use of transform signals, frequencies and coefficients instead of the multiplying coefficients (89, 93, 97, 99).

Detailed Description Paragraph Right (339):
FIG. 48 is a high level block diagram of the data transmission system 3001 comprising a transmitter 3013, and a receiver 3021, according to the present invention. While the data transmission system 3001 is described in relation to a digital modem and data signals, it should be understood that the present invention could be combined with the teaching herein, and applied to various transmission systems, and to signals other than data signals.

Detailed Description Paragraph Right (356):
Of these signals, it is expected that the signal F1 be distorted the most. The signal Sfd could be transmitted over a video (or another) carrier frequency, and modulated with other signals, as described herein. However, for illustration and specificity, the signal Sfd will be considered herein, as if it were transmitted directly to the receiver 3021, for use in facsimile machines, modems, or personal computers or devices equipped for receiving data. It should be pointed out however, that when the signal Sfd is transmitted over a video carrier frequency, noise generated during transmission includes signals at that carrier frequency. Consequently, when the original transmitted signal Sfd is to be recovered, noise at the carrier frequency could be filtered out, along with the carrier frequency, thus eliminating a significant and undesirable noise component.